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CROSS CONNECTIONS BETWEEN INDUSTRIAL AND PUBLIC WATER SUPPLIES*

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PROBABLY no feature of the public health aspect of water supply has been so great a cause for controversy as the cross connection of private industrial fire or process water supplies with public supplies.

Cross connections as applied to waterworks systems are relatively short lengths of pipe, with or without valves, which connect the public distribution system with a private distribution system, the latter system being supplied from an independent source. Frequently, the private supply is polluted; hence the public health aspect.

The danger from cross connections lies in the possibility that polluted water from the private supply may enter the public supply through leaky gates or checks, or directly when no gates or checks occur on the cross connection, at times when the pressure on the private supply is in excess of the pressure on the public supply.

TYPES OF CROSS CONNECTIONS

One of the cross connections frequently met with is that between the public mains and the hydrant and sprinkler system of an industrial establishment. The purpose of the connection is to maintain a constant head of water from the public system upon the mill fire hydrants and sprinklers and at the same time have an additional independent supply available in case of fire. Usually the mill supply is furnished by pumps of relatively large capacity, the starting of which involves a moderate amount of delay. Consequently, the connection of the public supply with the fire protection system of the mill means an immediately available supply of water for hose streams and sprinkler heads.

Another type of cross connection occurs where an industrial supply

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system used for furnishing process water is cross connected with the public mains. The purpose of such cross connections is to insure an uninterrupted supply of water for process purposes or for other uses which are not directly connected with fire protection; among these uses are boiler feed, stock washing, cooling, and quenching.

Cross connections may be classified according to their physical characteristics, namely:

1. Permanent connections where dual pressure supplies are physically connected through pipes either with or without gate valves or check valves.

2. Temporary connections where dual supplies are connected with a swing joint.

3. Temporary connections where supplies are connected by a removable length of pipe.

4. Connections through tanks open to atmospheric pressure. In this fourth type, two combinations occur:

a. Pipes from both supplies entering below water level;

b. The pipe from private supply entering above and that from public supply entering below water level.

In the case of the fourth type, should the pipe from the private supply enter below and that from the public supply enter above water level, there would be no possibility that water from the private supply might enter the public supply and consequently there would be no cross connection.

Outbreaks of Disease Due to Cross Connections

Numerous outbreaks of typhoid fever and intestinal disorders have been attributed to infection of public water supplies through cross connections. One of the earliest recorded occurrences of such infection was that at Lowell, Mass., in 1903[1] where check valves on cross connections between the municipal and private supplies failed to close subsequent to a fire. Polluted water from the Merrimac River entered the mains and resulted in an outbreak of dysentery, followed by 196 cases of typhoid fever with sixteen deaths. A recent outbreak (1927) of forty-seven cases of typhoid fever at Cohoes, N. Y.,[2] was attributed to water from the Mohawk River which entered the public supply mains through a cross connection with the public supply.

Many other instances could be cited. Published data indicate that in the past thirty years, in the United States, infection through cross connections has been responsible for thousands of cases of disease and scores of deaths.

In considering the records of outbreaks of disease, however, it must be borne in mind that no outbreak, so far as is known, has been traced to properly installed and supervised cross connections made by means of the modern type of double check valve. This is significant as far as it goes, but it is, of course, no proof that such an event may not occur in the future.

Regulation of Cross Connections

Conflicting Interests

The potential danger of cross connections is manifest and the urgency

[1] Goudey, R. F.: The Menace of Cross-Connections in a Public Water Supply. Jour. Am. Water Works Assn., 1926, *15*, 477.

[2] Cross-Connections again Responsible for Typhoid. N. Y. State Dept. Health, Health News, 1927, *4*, 185.

of their abolition in the majority of cases is granted, but in certain other cases how to avoid the health hazard without increasing the fire hazard is a matter concerning which unanimity of opinion does not exist.

The fire protection interests claim that the widespread use of automatic sprinkler systems has been a factor of great economic importance in industry and that in order to secure the most benefit from such systems a continuously adequate water supply is essential. Sprinklers must always be under pressure in order that incipient fires may be controlled. Public water supplies are sometimes deficient in quantity and pressure. Many instances have been recorded of interruption of service from public supplies and in a few cases coincident fires have occurred. Consequently, the insurance companies reason, a secondary supply is needed in those cases where the fire hazard to life and property is particularly great, and cross connections are called for under certain conditions.

On the other hand, many waterworks and health officials point out that the health hazard from possible pollution through cross connections is so great that other means should be found to provide adequate fire service. The argument of this group is that the record of failure of old-fashioned, iron-body, single check valves, with subsequent outbreaks of disease, is so sinister that cross connections of a polluted private supply with a potable public supply should not be tolerated no matter if they are protected by carefully worked out mechanical devices, such as double check valves of the improved type described later.

To reconcile these conflicting viewpoints is difficult, and indeed impossible, if the ideals of both parties are to be secured. Compromise policies are always open to cross fire, but one-sided viewpoints are likely to lead to the adoption of unwise or impracticable policies. Rational compromises, perhaps wholly satisfactory to neither side, often actually accomplish results for the general public welfare where idealistic policies fail.

State Health Department Regulations

With recognition of the health hazard incidental to cross connections, certain state health departments have established regulations relating thereto. These regulations have varied from a flat prohibition of all such connections to a requirement for double check valves. Certain other state health departments, in the absence of authority to regulate, have adopted resolutions advising the abolition of all cross connections.

An amendment to the Sanitary Code of the Public Health Council of the New York State Department of Health in 1925 prohibited cross connections between nonpotable and potable water supplies, but permitted the use until July 31, 1928, of connections equipped with two gate valves with indicator posts and two check valves equal to or of the type recommended by the Factory Mutual Fire Insurance Companies.

During the past summer, the development of a special fire pump chlorinator led the Public Health Council to grant an extension of six months. Following this action of the Council, the state commissioner of health advised the waterworks authorities throughout the

state that the installation and proper maintenance of the newly developed fire pump chlorinator would meet the requirements of this Sanitary Code. Such installations can be made only under certain conditions, among which is the proper installation of all-bronze, double check valves between the chlorinated fire supply system and the municipal system.

The Connecticut State Department of Health has required the abolition of all cross connections except those which are equipped with approved types of double check valves, in which case permission for temporary continuance has been granted. The length of continuance is conditional upon demonstration of satisfactory operation of the double check valve installations. No new installations of double check valves, however, are permitted.

In Ohio, Section 1,252–3, of the General Code of the state reads as follows:

> It shall be unlawful for any official, officer, or employee having in charge or being employed in the maintenance and operation of a public water supply and water works system or for any other person, firm or corporation to establish or permit to be established any connection whereby a private, auxiliary or emergency water supply other than the regular public water supply may enter the supply or distributing system, unless such private, auxiliary or emergency water supply, and the method of connection and use of such supply shall have been approved by the State Department of Health.

The Ohio State Department of Health does approve under certain restrictions the use of modern double check valve installations.

Action by Professional Societies

The Fire Protection Division of the American Water Works Association adopted the following resolutions[3] in May, 1925:

> WHEREAS cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases; and
>
> WHEREAS check valves and other similar protective devices can not always be depended upon; Be it
>
> *Resolved*, That no physical connection should be permitted between a potable public water supply and any other supply except as follows:
>
> 1. With another potable public supply.
> 2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.
>
> This prohibition to apply to all piping systems either inside or outside of any building or buildings; and be it further
>
> *Resolved*, that definite programs should be inaugurated in each municipality to permanently eliminate all other connections.

A similar set of resolutions was adopted in 1926 by the Conference of State Sanitary Engineers.

On December 12, 1928, a New England Water Works Association committee, composed of consulting sanitary engineers, waterworks superintendents, state sanitary engineers and fire protection engineers, reported on cross connections to the Association and presented the following resolutions for consideration by the Association:

> WHEREAS, evidence shows that the existence of certain cross-connections between safe public water supplies and unsafe

[3] Jour. Am. Water Works Assn., 1925, *14*, 505.

private water supplies, not equipped with modern protective devices, has resulted in many out-breaks of disease and many deaths, and

WHEREAS, such cross-connections are a hazardous part of any water-supply system.

1. This Association recommends that no cross-connection be permitted with a supply that in the opinion of the State health authorities is bacterially unsafe.

2. This Association recommends that any cross-connection permitted with a bacterially safe but non-potable supply shall be made through a properly installed and adequately supervised, all-bronze, rubber-seated, double check-valve of a type approved by the State health authorities.

These resolutions were approved at the meeting of the Association at which the report was presented but were referred by letter ballot to the Association as a whole for approval or disapproval. This ballot resulted in an emphatic endorsement of the resolutions by the Association. The full report of the committee will appear in the March, 1929, number of the *Journal of the New England Water Works Association.*

At the annual meeting of the National Fire Protection Association in May, 1928, a report of a Committee on Private Fire Supplies from Public Mains contained the following statement relative to the position of that Association:

1. The National Fire Protection Association is in full sympathy with the efforts being made to maintain the purity of public water supplies. It recognizes a public duty in bringing fire protection requirements into harmony with the best public health standards.

2. Fire protection engineers should not advocate cross connections with non-potable supplies for fire service when it is feasible to safeguard life and property in some other way.

3. No fixed rule can be adopted for all situations, and each case must be carefully studied to determine the most reasonable arrangement under the existing conditions.

4. The chance that the best double special check valves properly supervised might, under conceivable conditions, both leak at the same time has been conceded, but experience of eighteen years over a wide field and under many different conditions has shown that this danger is extremely remote. It is therefore believed that double special check valves of the latest improved all-bronze type can be used under certain conditions with a negligible degree of risk, but only if properly installed and adequately supervised.

5. Public regulations concerning cross connections should have reasonable flexibility so that double special check valves or other equally effective devices properly supervised would be allowed for fire services where conditions justify their use.

DOUBLE CHECK VALVES

In order to minimize the danger of pollution through cross connections, the Factory Mutual Insurance Companies have developed a bronze-body, double check valve as illustrated in Figure 1.

To insure tight closing, the clappers are provided with soft rubber gaskets to bear against the machined seats. For ready inspection and test these valves are placed in concrete pits. Gate valves with indicator posts are placed on either side of the checks and drain cocks, and connections for pressure gauges are also provided. To prevent both clappers from being held open by a long piece of foreign material a modified installation, as illustrated, has a filler piece, a few feet long, between the checks.

Only within recent years have there been any readily available data relative to the effectiveness of double check valve installations. Of 1,032

sets of such installations tested by the Factory Mutual Fire Insurance Companies, four cases were found where both valves were leaky. These companies have recently put into effect a system of supervision of all double check valves at risks which they insure, and they require that every valve be thoroughly overhauled and cleaned annually in addition to being tested four times each year. At New Bedford, Mass., both checks were found leaky in two cases out of 2,152 tests covering several years. In Connecti-

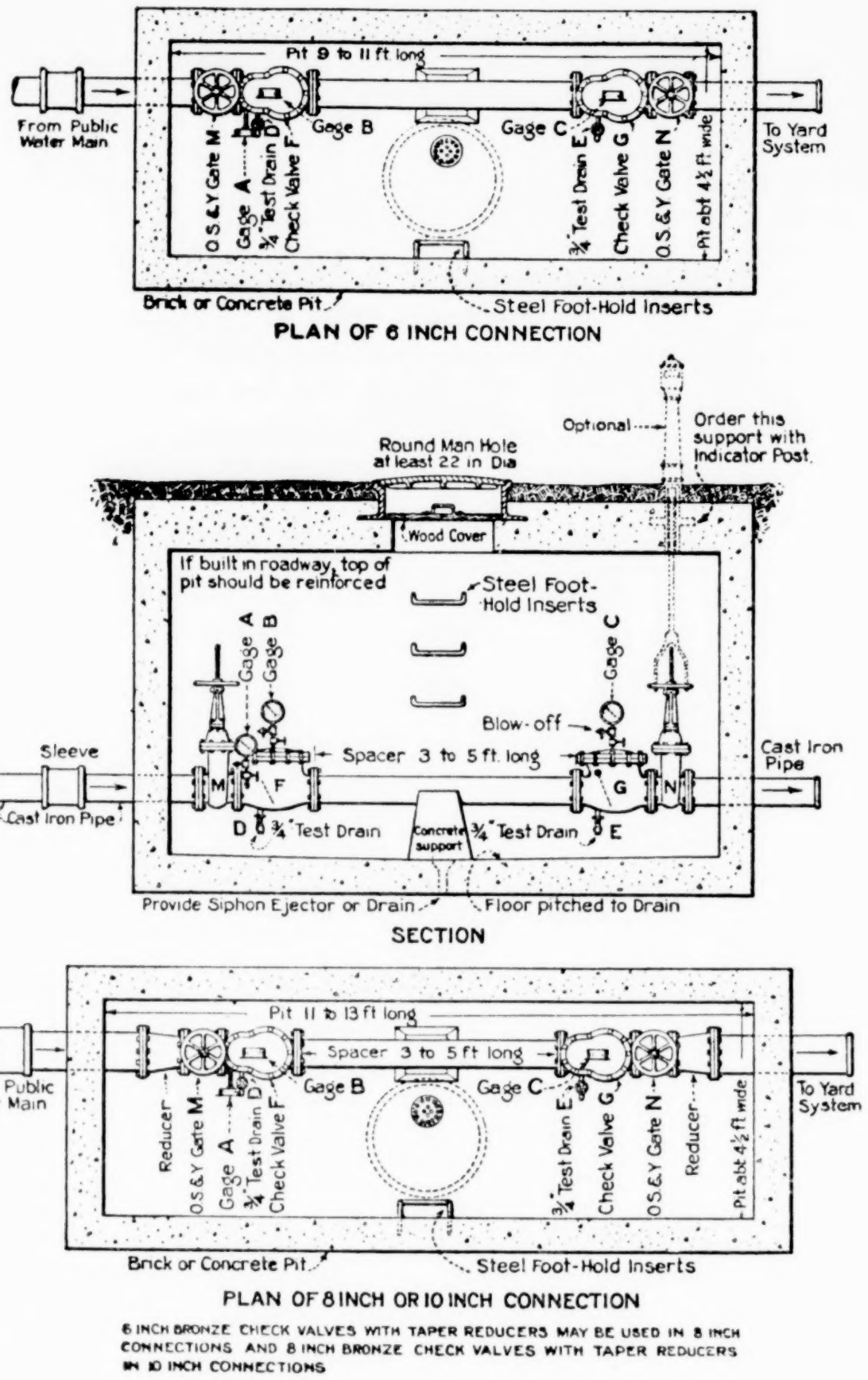

FIG. 1.—Type of double check valve installation developed by the Associated Factory Mutual Insurance Companies, through whose courtesy this cut is used.

cut, inspections by the state health department during 1927 found both checks leaky in one case out of 624 tests of iron-body, double check valves, while in 273 tests of all-bronze, double check valves there was no case where both checks were leaky. In connection with the Connecticut tests it should be noted that the iron-body valves had practically all been recently overhauled, but few were new, and the bronze valves were all new.

It is evident that the proper installation of double check valves involves considerable expense. Consequently, it is but fair to manufacturers, to whom temporary approval of such devices is given by health authorities, that such approval should cover a reasonable period of time, probably not less than two or three years. If conditions are so serious as to warrant a shorter period, it would be better to insist on complete severance at once. On the other hand, permission for use of double check valves should be immediately revocable for cause.

Fire Pump Chlorinator

During 1928 there was developed an automatic start-and-stop chlorinator designed particularly for connection to fire pumps. This apparatus utilizes liquid chlorine by reducing it to a gas. While the fire pump is not in operation a small auxiliary injector continually draws a small amount of chlorine gas and discharges it to waste, thus keeping the machine in continuous operation. When the fire pump starts, a large main injector draws the chlorine and discharges it in solution to the point of application on the fire pump suction. The chlorinator is set to discharge a quantity of chlorine sufficient to care for the maximum discharge from the pump irrespective of actual delivery.

Conclusion

No question exists as to the potential hazard to health resulting from the cross connection of polluted private industrial water supplies with public supplies. No valid reason exists for such connection in the great majority of cases. Under some conditions, however, the immediate abolition of cross connections with fire protection systems would result in an increased fire hazard to property and to the safety of mill employees out of proportion to the results to be gained. Under such special cases, the all-bronze, double check valve, properly installed, regularly and thoroughly inspected, tested, and overhauled, affords as reasonably efficient a single mechanical safeguard, short of complete physical severance, as has yet been devised. Some risk of pollution remains as indicated by the results of tests cited. The development of the special fire pump chlorinator offers an additional safeguard, but experience with it has been too limited as yet to warrant the conclusion that the combination of double check valves and special chlorinators is equal to complete severance. Consequently, ultimate abolition of all cross connections, or its equivalent, between safe and unsafe supplies should be the goal. Pending such abolition, all cross connections, except those with proper double checks, should be immediately severed.

THE DUST HAZARD IN THE ABRASIVE INDUSTRY: SECOND STUDY*

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IN 1925 the author and the late E. B. Simmons presented a paper on "The Dust Hazard in the Abrasive Industry,"[1] In this paper the medical histories, physical examinations, and X-rays of seventy-nine men who had been exposed to large quantities of artificial abrasive dust over a period of more than ten years were analyzed, and certain conclusions as to the hazard of inhaling this type of dust were stated.

The paper now undertaken presents:

1. A review of the subsequent histories of the seventy-nine men previously studied.

2. A comparison of the X-ray findings of 1924 with those of 1928 in the same group.

3. A report on the X-ray findings of the other groups of men who have been exposed ten years or more to abrasive dust inhalation.

4. Conclusions.

All the men discussed in this study are working and are apparently in good health at the present time. Each one has had a special physical examination of the chest yearly since he passed the ten-year dust exposure mark. In no case has the physical examination revealed any lesion, nor have there been in any case symptoms suggesting a chest lesion of any kind.

The X-ray pictures have been taken and read by Dr. Morton Langhill of Worcester. The first group of pictures described in the previous paper, examined by Dr. Jarvis, has also been submitted to Dr. Leroy U. Gardner of Saranac for reading, as have all but twenty-three films of the later groups. Where readings have differed, we have used the less favorable in making up our tables. There has been, however, little divergence of opinion. We have used the classification of silicosis advocated by Pancoast and Pendergrass[2] in their monograph, which is as follows:

First Stage.—The root shadows are denser, and more extensive, and may show nodules; the trunk shadows are increased in density and breadth, with numerous punctate deposits of varying size along them; the appearance is symmetrical on both sides at first, but not so later; there is no difference in diaphragmatic excursion.

Second Stage.—In addition to the foregoing, there are found fairly symmetrical, small, circumscribed, dense areas throughout both lungs, and later larger masses accumulate, usually at the lower part of the upper third, about the level of the root shadows; the domes of the diaphragms seem accentuated.

Third Stage.—This differs from the second only in the extent of lung involve-

* Received for publication Nov. 3, 1928.

[1] This Jour., 1925, 7, 345.

[2] Pancoast, H. K., and Pendergrass, E. P.: Pneumoconiosis (Silicosis). A Roentgenological Study with Notes on Pathology. New York, Paul B. Hoeber, Inc., 1926, p. 52.

ment, indicated by increased numbers of deposits and more massive grouping.

The majority of the chest pictures of Norton Company employees included in this series showed minimal or first stage changes. We have had pictures taken of the chests of a number of workers who have not been working in dust but who have had definite chest symptoms such as cough and expectoration. Our effort was to discover early cases of pulmonary tuberculosis. We have been interested to note that in many of these cases the report of first stage silicosis has been made.

We believe that a general low-grade inflammation of the bronchi will give a first stage picture and also that men advanced in years frequently show a first stage picture without having been exposed to dust. In other words, chests of those having chronic bronchitis, or of those who are middle-aged, will frequently on X-ray give a picture similar to that of a first stage silicosis.

Of the original group of seventy-nine cases reported in our previous paper, sixty-nine have worked without symptoms or serious illness up to the present time. Of the ten no longer working, four have left the employ of the Company and cannot be traced, and six have died. The percentage of deaths in the group was therefore 7.5.

The causes of death were as follows:

Cause	*Number of Deaths*
Carcinoma of stomach	1
Acute lobar pneumonia	2
Acute bronchopneumonia	1
Appendicitis and peritonitis	1
Tuberculosis of lungs	1

A comparison is here shown, in Table 1, of 69 X-ray pictures taken in 1924 and the same chests pictured in 1928. It will be seen that, of these 69 chests, 12 showed no silicosis in 1928, 11 showed early signs, 43 had the picture of first stage silicosis, while but 3 showed second stage silicotic changes, probably a true silicosis. In those cases showing the picture of second stage silicosis, 2 had worked many years in a department where there was much clay dust, containing 9 per cent. of free silica, and 1 had been exposed only to abrasive dust inhalation.

Therefore, of the entire group of workers who have been longest exposed to the hazard of artificial abrasive dust inhalation over periods varying from fifteen to forty-two years, only one showed signs of second stage silicosis. This man had been exposed for a period of twenty-six years.

During these examinations the X-ray revealed four cases of unsuspected healed tuberculosis. Careful physical examination failed to elicit any signs of activity and the workers are without symptoms.

In 1927 X-ray pictures were taken of another group consisting of all men working in dusty departments who had been exposed to the hazard of dust inhalation for over ten years and who were not included in the group analyzed above. Forty-five men appeared on this list, and Table 2 gives the basic facts and the stage of silicosis found.

It will be noted that, of a total of forty-five workers, twenty showed no silicosis on X-ray, twenty-two showed a first stage picture, while three showed

TABLE 1.—COMPARISON OF STAGES OF SILICOSIS SHOWN BY SIXTY-NINE X-RAY PICTURES OF CHESTS TAKEN IN 1924 AND 1928

NAME	AGE	WEIGHT	LENGTH OF EXPOSURE	STAGE OF SILICOSIS	
				1924	1928
		lbs.	*yrs.*		
A. A.	72	186	42	Minimal	First
J. A.	50	194	18	Minimal	First
A. H. A.	38	159	24	First	First
C. A.	41	142	25	Early First	First
J. W. A.	44	144	18	None	Early First
O. A.	63	175	20	None	First
J. B.	55	146	37	None	First
O. B.	44	133	26	None	First
W. B.	54	237	18	Early First	First
A. B.	56	198	30	None	First
C. B.	39	168	16	None	First
A. C.	45	176	18	None	First
C. C.	43	159	19	First	First
C. J. C.	58	250	17	First	First
C. C.	56	148	21	Normal	First
C. C.	51	142	16	Minimal	Minimal
G. C.	43	168	25	First	First
I. C.	51	203	19	Minimal	First
C. H. L.	40	163	21	First	First
C. L.	58	202	18	Second	First
W. L.	45	163	18	None	Early First
A. H.	57	190	17	None	None
W. L.	35	151	16	None	Early First
A. L.	36	174	18	None	Early First
I. M.	67	153	25	None	First
E. M.	40	187	20	First	First
K. M.	53	159	18	Early First	First
W. N.	37	170	21	Early First	First
J. N.	49	110	24	None	None[1]
H. O.	67	145	24	None	Late First
I. O.	38	193	16	None	First
G. P.	45	177	22	None	None

[1] Healed tuberculosis.

TABLE 1.—*Continued*

NAME	AGE	WEIGHT	LENGTH OF EXPOSURE	STAGE OF SILICOSIS	
				1924	1928
		lbs.	*yrs.*		
G. P.	47	196	21	First	First
J. P.	64	149	23	First	First
N. P.	39	140	16	Minimal	First[1]
I. R.	56	135	21	None	None
C. S.	39	136	19	None	Early First
H. T. S.	41	168	16	None	First
N. C.	47	188	22	First	Early Second[2]
J. P. C.	37	177	18	None	Early First
J. C.	37	170	19	None	First
N. E.	42	183	26	None	None
K. E.	39	151	28	Early First	First
F. F.	66	105	43	First	First
C. F.	45	201	19	First	First
A. F.	69	175	21	None	First
G. F.	58	158	38	Second	First
C. G.	39	176	15	First	Early First
I. H.	47	162	18	None	None[1]
C. J. H.	57	140	26	Early First	First
E. H.	40	144	17	First	First
A. H.	42	156	16	First	First
A. J.	34	195	16	First	First
E. J.	56	145	35	Second	Second[2]
E. J.	55	140	16	None	Minimal
E. J.	43	178	24	None	None
G. J.	47	214	18	None	Early First
G. F.	64	124	21	None	First
G. R. J.	47	154	18	None	None
J. J.	52	191	26	First	Second
M. S.	31	150	16	None	None
F. B. S.	31	148	18	None	None
J. S.	56	144	18	None	None
J. W.	41	182	16	First	First[1]
V. W.	38	174	15	None	None
F. A. W.	39	133	19	None	First
J. P. W.	68	122	16	First	First
N. W.	55	154	25	Minimal	Minimal
J. R.	62	195	19	First	First

[2] Exposed to clay dust containing 9 per cent. of free silica.

TABLE 2.—STAGES OF SILICOSIS SHOWN BY FORTY-FIVE X-RAY PICTURES OF CHESTS, 1927

NAME	AGE	WEIGHT	LENGTH OF EXPOSURE	STAGE OF SILICOSIS
		lbs.	*yrs.*	
A. A.	37	140	11	None
G. B.	43	149	12	First
M. B.	53	186	13	Late First
H. B.	32	144	13	None[1]
W. C.	42	131	13	Second
A. C.	33	170	12	None
J. S. C.	45	171	12	None
O. C.	40	126	12	None
V. D.	32	150	12	None
F. D.	42	141	11	First[1]
J. D.	56	166	11	First
C. D.	45	170	13	First
C. E.	61	228	12	First
A. E.	45	147	11	First
E. H.	42	203	13	Second
T. H.	57	160	12	First
A. J.	36	187	11	None
A. J.	42	155	13	None
C. J.	37	128	20	None
C. J.	42	163	12	First[1]
F. J.	33	148	11	None
J. J.	46	146	12	First
J. J.	52	135	10	None
J. S. J.	51	173	12	None
J. K.	32	130	10	First
W. M. M.	38	145	11	First
A. McL.	43	129	11	None
T. M.	44	165	11	None
L. M.	60	152	10	None
R. M.	49	140	11	First
A. M.	36	185	12	First
C. M.	56	139	12	First[1]
M. M.	33	135	12	First
C. W. N.	42	199	10	Second
V. N.	34	146	14	None[1]
G. N.	57	178	13	First
F. P.	36	188	12	First
C. P.	41	167	16	First
A. P.	41	190	13	First
G. P.	54	185	12	None
E. Q.	42	190	12	None
F. R.	58	159	12	First
J. T.	45	158	11	None
C. V.	32	183	11	None[1]
M. Z.	49	124	14	First[1]

TABLE 3.—STAGES OF SILICOSIS SHOWN BY TWENTY-THREE X-RAY PICTURES OF CHESTS, 1928

NAME	AGE	WEIGHT	LENGTH OF EXPOSURE	STAGE OF SILICOSIS
		lbs.	*yrs.*	
M. A.	45	189	11	First
V. B.	34	185	11	First
M. B.	31	138	12	None
V. D.	34	138	10	None
D. F.	33	135	11	First
A. G.	38	148	12	First
A. J.	44	121	11	None
A. J.	38	156	19	First
J. E.	44	190	10	None
P. K.	31	169	12	Early First
N. L.	64	144	13	First
M. L.	64	146	12	None
I. N.	51	159	15	First
C. O.	35	150	14	None
O. O.	32	158	18	First
P. P.	39	165	13	None
J. R.	53	176	11	None
F. R.	32	134	10	None
T. R.	44	140	11	First
C. S.	48	199	11	None
K. S.	49	187	10	First
J. T.	62	165	10	First
J. W.	34	151	12	First

[1] Healed tuberculosis.

second stage, a larger proportion than in the older group. Again, we were surprised to find seven cases of unsuspected healed pulmonary tuberculosis.

In 1928 a third group, consisting of twenty-three men who had just completed ten years' work in dusty departments, was X-rayed. The results are shown in Table 3. It will be noted that there were ten who showed normal lung pictures, thirteen who showed first stage changes, and none who showed second stage cases. No cases of tuberculosis were found.

Reviewing the three groups as a whole, the total number of cases of exposure to large doses of dust, mostly artificial abrasive, over periods varying from ten to forty-two years, was 137. Of these, forty-two showed no silicosis, twelve showed slight silicotic change, seventy-seven the picture of first stage, and six the picture of second stage silicosis. Of the six, two had been exposed to large doses of clay dust containing 9 per cent. of free silica, four had been exposed to abrasive dust only. There were eleven cases in which the X-ray showed an old inactive tuberculous process in the lung.

Conclusions

The continued inhalation of artificial abrasive dust composed of aluminium oxide or silicon carbide will not produce disabling silicosis in the working period studied.

The X-ray pictures fail to reveal any cases of third stage silicosis.

It is possible for men with arrested tuberculous processes of the lung to work in artificial abrasive dust for a considerable period without relighting the process.

J. I. H.
March, 1929

ABSENTEEISM IN COAL MINERS*

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INTRODUCTION

ABSENTEEISM in coal miners is usually so considerable as to be of great economic importance. Evidence given before the Royal Commission (1) indicated that in 1924 the whole body of miners in Great Britain were absent, on an average, for 8.5 per cent. of the 268 days when work was available for them. The actual loss of working time is much greater than is indicated by this percentage, as the coal hewers and "trammers," who work at the coal face, show much more absenteeism than the other underground men, who are chiefly concerned in the haulage of the coal and are dependent for their work on the hewers. We have recently made an analysis of the absenteeism shown by nearly 23,000 miners employed at a group of ten collieries (2), and we found that the time lost by the coal face men averaged 15.8 per cent., that lost by the other underground men being 9.7 per cent., and that by the surface men, only 7.7 per cent. Probably absenteeism in the coal mines of the United States is similar to that observed in Great Britain, for a survey made by Haywhurst (3) on about 22,000 men employed in ninety-nine mines in Ohio and Illinois during the summer of 1918 gave an average absenteeism of 10 per cent.

Only by tracking down the various causes which contribute to this absenteeism can we hope to be able to apply appropriate measures for its reduction. We therefore analyzed the absenteeism statistically, according as it was due to accidents, sickness, or other causes, and endeavored to discover how far the varying conditions of work influenced absenteeism from each of these three main causes. We were able to obtain statistics of the total time lost for the years 1920 to 1926, and of the time lost by accidents for the years 1924 and 1925. Sickness data were available for a twenty-one-month period (Aug., 1924, to April, 1926), and were obtainable only at seven of the collieries investigated. We were specially interested in the influence of underground atmospheric conditions on absenteeism, so we made numerous observations on these conditions at all of the pits. Altogether we made 280 sets of observations on air temperatures and velocities at the coal face, and 191 in the haulage roads.

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Absenteeism Due to All Causes Combined

The pits investigated varied in average depth from 616 to 2,269 feet at the coal face, and on splitting them into three groups, according to their depth, we found that there was a fairly close correspondence between depth and absenteeism. It can be gathered from the data adduced (Table 1) that coal face men working at an average depth of 2,160 feet showed 23 per cent. more absenteeism than those working at a depth of 651 feet, while the other underground men showed a 46 per cent. excess. This rise in absenteeism was very largely due to the increasing temperature, for it is well known that underground temperature increases fairly regularly with depth. We ourselves observed the following mean relationships between depth and temperature at the mines investigated by us:

Depth of Workings	*Dry Bulb Temperature*
ft.	*°F.*
500	63.6
1,500	76.3
2,500	89.0

Temperature is not nearly so important a consideration in American mines as it is in those of Great Britain, as for the most part the former are considerably shallower and cooler. The temperature of the mines in Ohio and Illinois mentioned above varied from 50° to 70° (dry bulb); but the humidity was high, while in the mines surveyed by us it was moderate.

On splitting up the absenteeism into the three categories already mentioned, we found that about half of it was due to voluntary causes, while of the remainder sickness accounted for nearly twice as much lost time as did accidents (Table 2).

TABLE 1.—ABSENTEEISM IN RELATION TO DEPTH OF WORKINGS

RANGE OF DEPTH	MEAN DEPTH	TIME LOST BY	
		Coal Face Men	Others Underground
ft.	*ft.*	%	%
Under 1,000	651	13.8	8.1
1,000–1,999	1,592	15.4	9.1
2,000 and over	2,160	17.0	11.8

TABLE 2.—ANALYSIS OF ABSENTEEISM BY CAUSE

CAUSE OF ABSENTEEISM	TIME LOST BY	
	Coal Face Men	Others Underground
	%	%
Sickness	4.3	3.3
Accidents	2.7	1.5
Voluntary causes	8.8	4.8

Absenteeism Due to Sickness

The time lost from sickness was found to vary considerably with the temperature. Taking averages for all the collieries, according to their mean temperature, we found the relationships between temperature and sickness indicated in Figure 1. It will be seen that coal face men, when working at an average temperature of 68° (dry bulb), lost 3 per cent. of their time, while at 81° they lost

4.9 per cent., or 63 per cent. in excess. The other underground men responded even more, for their sickness at 76.5° was 74 per cent. greater than at 66.7°. When the sickness was calculated in relation to the wet bulb temperature it showed a similar rate of increase. Surprise may be felt at this very marked effect of underground temperatures on sickness, for many dwellers in warm climates habitually experience higher temperatures than those investigated by us, without ill effects. Presumably the causation of the sickness depends, not on the high temperatures at which the miners perform their work, but on the sudden changes experienced when coming to the surface. Sometimes the surface air temperature is 50° lower than that underground, and an overheated and freely perspiring man, on emergence into such cold air, would be very liable to catch a chill.

Sickness was found to increase with increase in air velocity, as can be judged from the data adduced (Table 3). This is readily understandable with regard to the underground men other than the coal face workers, for they had to work in air with a fairly considerable velocity, but we see that an increase in the velocity from 24 to 53 feet per minute caused a distinct rise in the sickness of the coal face men. Probably this was due to the tendency of the men to catch chills, as many of them are stripped to the waist while at work, and stream with perspiration. From time to time they may have to wait for twenty minutes or more owing to lack of trucks into which to load the coal, and unless they take the precaution of temporarily putting on clothes, even very moderate air currents may chill them.

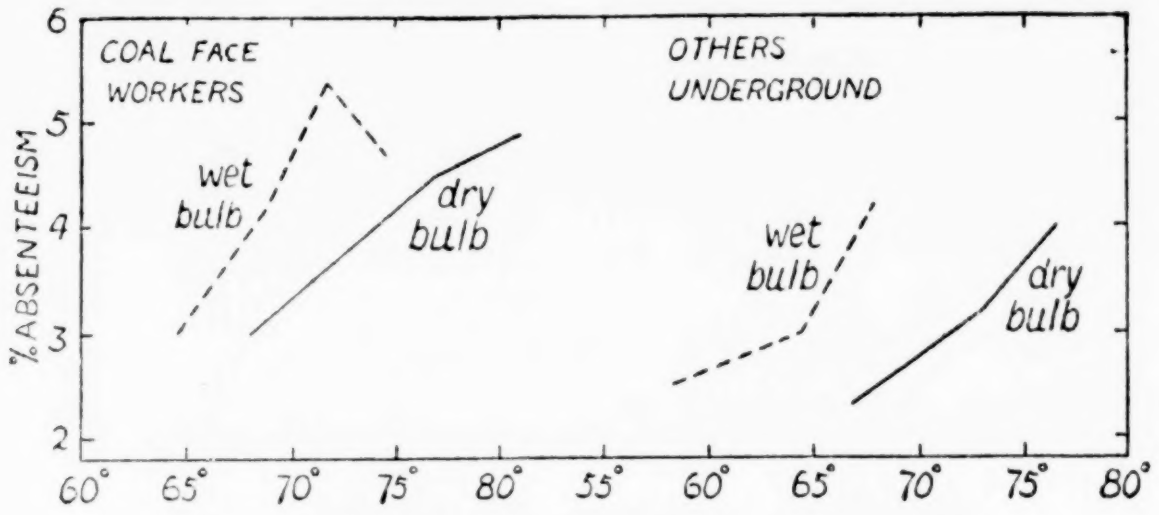

FIG. 1.—Relation of sickness to temperature.

TABLE 3.—ABSENTEEISM DUE TO SICKNESS IN RELATION TO AIR VELOCITY

RANGE OF AIR VELOCITY	MEAN VELOCITY	TIME LOST BY	
		Coal Face Men	Others Underground
ft. per min.	*ft. per min.*	%	%
Under 30	24	3.7	...
30– 59	53	4.3	...
60–119	82	5.5	2.7
120–159	137	...	3.1
160–199	171	...	3.1
200 or more	264	...	5.0

As might be expected, sickness increased with the age of the men. Coal face men aged 31.5 years lost 3.5 per cent. of their time, those aged 34.1 losing 4.3 per cent. of it, and those aged 39.7, 5.1 per cent. of it. The other underground workers showed an even greater rise with increasing age.

Absenteeism Due to Accidents

In Great Britain all accidents are reported which involve an absence of over three days from work, as compensation is then paid. Accidents to coal miners cause a greater mortality than that observed in any other industry; in 1913 to 1922, fatal accidents were at the rate of 1.2 per 1,000 men employed. This rate is considerably lower than that observed in American mines, where it was 4.3 per thousand in bituminous coal mines, and 4.4 in anthracite mines (4). These figures are calculated on the hypothesis that the men were working for 300 days a year. Usually they work considerably less than this, and in 1922 to 1923 the actual death rate per 1,000 men below ground was 2.94 in American mines, and 1.14 in British mines (1). The greater frequency of accidents in America is probably due in large part to the greater thickness of the seams. We found that in six collieries where the same seam was worked, the accident rate from falls of coal was four times greater where the seam was 72 inches thick than where it was 44 inches thick. Table 4 records the frequency in terms of accidents per 100,000 shifts, and the severity in terms of days lost per 1,000 hours worked.

Of the coal mined in Great Britain in 1924, 49 per cent. came from seams less than 4 feet in thickness, and only 10 per cent. from seams of over 6 feet. We understand that in America very

TABLE 4.—ACCIDENT RATES FROM FALLS OF COAL IN RELATION TO THICKNESS OF SEAM

COLLIERY	DEPTH OF WORKINGS	THICKNESS OF SEAM	ACCIDENT FREQUENCY[1]	ACCIDENT SEVERITY[2]
	ft.	*in.*		
P	1,850	44	9.0	0.32
N	1,386	50	12.7	0.45
L and Q	1,764	66	29.9	0.99
M and J	1,514	72	37.0	1.30

[1] Accidents per 100,000 shifts.
[2] Days lost per 1,000 hours worked.

TABLE 5.—ACCIDENT RATES IN RELATION TO AIR VELOCITY

RANGE OF AIR VELOCITY	MEAN VELOCITY	COAL FACE MEN		OTHERS UNDERGROUND	
		Accident Frequency	Accident Severity	Accident Frequency	Accident Severity
ft. per min.	*ft. per min.*				
Under 30	21	101	4.2	....	....
30– 39	33	107	3.4	....	....
40– 59	56	104	3.7	....	....
60– 79	72	140	4.2	....	....
80–149	106	....	....	60	2.1
150–249	193	....	....	64	2.2
250 or more	264	....	....	89	2.7

little coal is mined in seams less than 4 feet in thickness, while seams over 6 feet are numerous.

In order to discover if different classes of accident were affected differently by the conditions of work, we

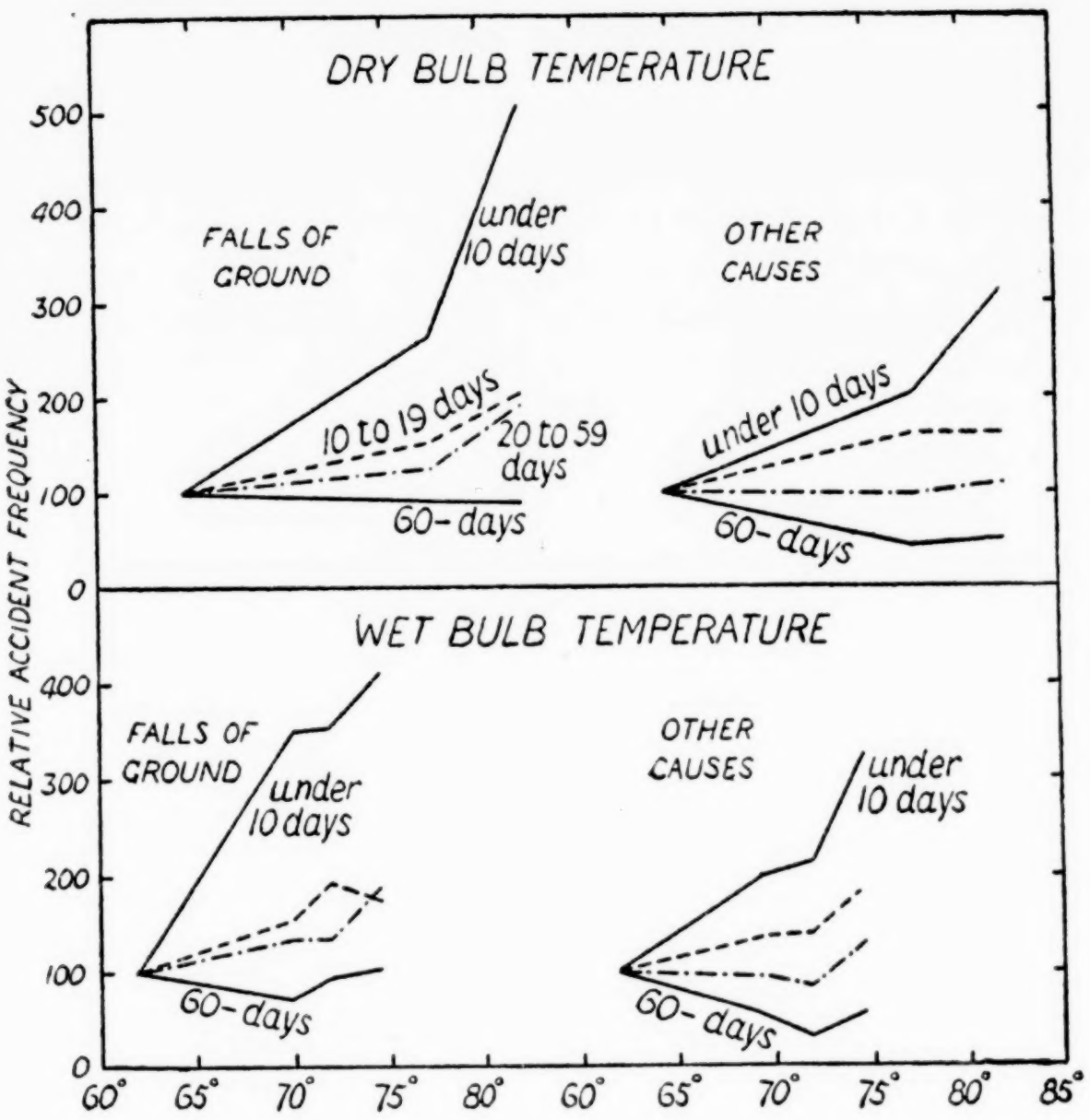

FIG. 2.—Accident disability of coal face workers in relation to temperature.

The accident rate was found to increase with increase in air velocity, just as the sickness rate did, except that at very low velocities (under 30 feet per minute) the severity rate for coal face men was distinctly greater than at higher velocities of 30 to 59 feet (Table 5). Probably the men, when waiting for the arrival of trucks, etc., tend to get rather stiff if they are exposed to more than very moderate air currents, and in consequence are more clumsy in their movements and more liable to incur accidents on resuming work.

split them up into accidents due to falls of ground (coal, roof, etc.), and those due to other causes. We also tabulated them according as they caused disablement for less than 10 days, for 10 to 19 days, 20 to 59 days, and for 60 days or more. We found that high temperature acted very differently on minor and on major accidents, and it will be seen from Figure 2 that for each 100 minor accidents (under 10 days' disablement) from falls of ground suffered by coal face men when working at a mean dry bulb temperature of 64.4°, there were

264 accidents incurred at a temperature of 77.3°, and 506 at one of 82.1°. The more severe accidents increased at a less rapid rate with rise in temperature, while severe accidents, causing disablement for 60 days or more, fell somewhat with rise in temperature. This particular result is probably rather misleading, and is due to the comparatively small number of accidents involved, for on grouping the accidents incurred at high dry and wet bulb temperatures by all the underground workers we found that they were of almost exactly the same frequency as those incurred at low temperatures. The minor accidents (under 10 days' disablement) were, however, 4.3 times more numerous at high temperatures than at low ones. The explanation of this remarkable difference of effect appears to depend, not on any difference in the number of accidents incurred, but on the frequency with which the men claimed compensation pay. If a man receives such a severe injury that he is disabled for over 10 weeks, there can be no question that he must stop work and claim compensation, whether he happens to be working in a cool and comparatively pleasant pit, or in a hot and unpleasant one. When, on the other hand, he receives a minor injury which disables him for 3 days or less (a period which is insufficient to entitle him to claim compensation), he may decide to return to work at once if he is in a cool pit. If he has been working in a hot pit, however, he may be more fatigued, and be more alive to the unpleasantness of his task, and may therefore decide to claim compensation for a time.

The explanation adduced may seem rather improbable, but support of it was obtained in other directions. The Chief Inspector of Mines (4) pointed out that while the number of severe accidents (from fractures, dislocations, etc.) suffered by the men during the last few years is almost constant, the number of minor accidents has risen rapidly, and in 1923 to 1925 it was half as great again as in 1920. Coincidently with this increase in minor accidents the yearly earnings of the men fell nearly to a half. Though part of this fall was neutralized by a fall in the cost of living, the fall in real wages was sufficient to decide many of the men to claim compensation pay when they incurred minor accidents. Again, we found that the frequency of minor accidents varied with the degree of contentment of the men with their work, as indicated by the extent of the labor turnover. Turnover is probably lower in Great Britain than in America, as the mining population is more stable, but we found a turnover of more than 30 per cent. per annum at one pit, and one of 20 to 30 per cent. at several others. We found that at the pits where it was over 20 per cent. the frequency of minor accidents (causing less than twenty days' disablement) was three times greater than at pits where it was less than 10 per cent., while the frequency of more severe accidents was unrelated to turnover.

The variations of accident rate with age gave a striking proof of the fatigue of the coal miner's work. It is well known that the accident rate tends to decrease as the experience and age of the workers increase. For

instance, Chaney and Hanna (5) found that the rate of accidents suffered by the men employed at a large steel works fell steadily with length of service, till it reached zero

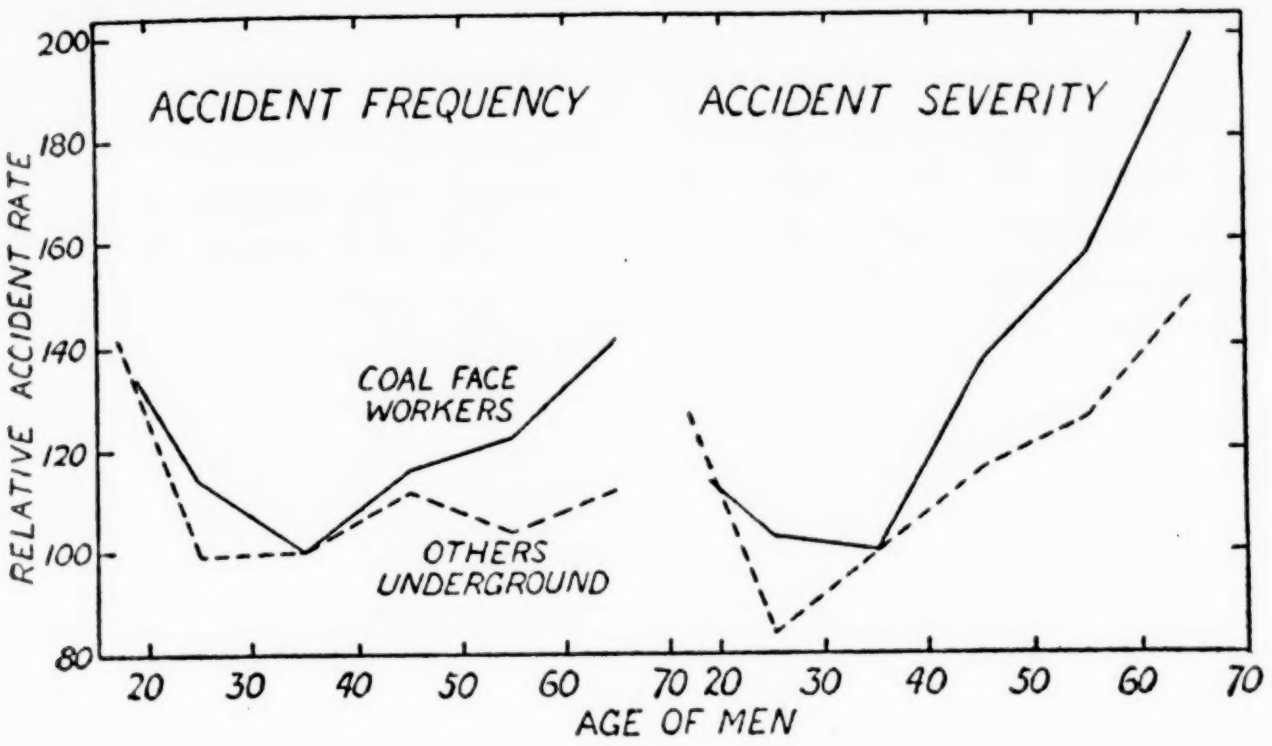

FIG. 3.—Accident rates in relation to the age of the men.

with men of over fifteen years' service. Kitson and Campbell (6), who obtained information relating to nearly 29,000 accidents incurred in the manufacture of motor cars, railway cars, cutlery, and coke and gas, found that the accident rate varied synchronously with the number of new men employed. We ourselves found that the accident frequency and accident severity rates of the men reached a minimum at an age of about 30 years, and then increased rapidly, as can be seen from Figure 3. At ages of 60 and over, the frequency rate of the coal face men was 1.4 times greater than at ages 30 to 39, while the severity rate was 2 times greater; *i.e.*, the older men not only incurred accidents more frequently, but they took much longer to recuperate from them.

ABSENTEEISM DUE TO VOLUNTARY CAUSES

As has already been mentioned, over half the absenteeism of the men was due to voluntary causes. The extent of this absenteeism was greatly influenced both by conditions of work in the pit, and by external conditions. For instance, underground workers other than those at the coal face lost 3.6 per cent. of their time voluntarily when they had to work at a (wet bulb) temperature of 58°, and 7 per cent. of it when they had to work at 68°. Again, they lost 4.5 per cent. of it when working in air currents of less than 160 feet per minute, but 8.8 per cent. of it when working in currents of 200 feet or more.

The men appeared to object very much to a long walk from the pit bottom to their working place, as it reduced the time available for work, which was paid at a piece rate. Thus we found the following relationships

between time lost voluntarily and distance walked underground:

Distance Walked yds.	*Time Lost Voluntarily* %
1,333	7.3
2,307	8.4
2,815	11.5

Again, we found that discontented men—as judged by their relatively large labor turnover—lost more time voluntarily than contented men having a small turnover (Table 6).

TABLE 6.—LABOR TURNOVER IN RELATION TO VOLUNTARY ABSENTEEISM

LABOR TURNOVER	TIME LOST VOLUNTARILY BY		
	Coal Face Men	Others Underground	Mean
%	%	%	%
9.6	8.0	3.2	5.6
20.8	8.2	5.9	7.1
27.1	9.9	5.6	7.8

The distance of the men's homes from the colliery had a considerable effect on voluntary absenteeism, for men living $2\frac{1}{2}$ miles away lost 9.5 per cent. of their time, while those who lived $1\frac{1}{2}$ miles away lost only 5.3 per cent. of it.

Conclusion

Our results suggest that, judging by the extent of his absenteeism, the coal miner is extraordinarily sensitive to his conditions of work and to his general environment. Any and every change of condition affects not only his voluntary absenteeism, but the time lost by sickness and accidents as well. The most valuable method of reducing absenteeism appears to be to improve the conditions of work. Sickness and accident rates for the most part tended to increase rather than to diminish with increase in air velocity, and this fact might be used as an argument against improving the ventilation; but it is probable that velocities of 18 to 21 feet per minute, such as were observed at the coal face in some of the pits, were a good deal too low for minimum rates. Even if better ventilation slightly increased the rates, it might be worth while to introduce it, for it would lower the high temperature of the air, which is such an important cause of absenteeism.

Coal miners in America (7) are probably more dependent on their employers for their homes and the conditions under which they work than is any other large group of workers; consequently our results should for the most part apply to these miners as well as to those in Great Britain.

Although close relationships have been observed by us between absenteeism and various environmental conditions, it does not necessarily follow that the relationship is a direct one. The two variables may be related indirectly, in some way not yet identified.

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BOOK REVIEW

LEHRBUCH DER HYGIENE FÜR STUDIERENDE, ÄRZTE UND GESUNDHEITSBEHÖRDEN. By Dr. med. et phil. *Ernst Gerhard Dresel*, o. ö. Professor der Hygiene und Direktor des Hygiene-Institutes an der Universität Greifswald. Paper. Pp. xii, 499 with illustrations, tables, and index. Berlin and Vienna: Urban & Schwarzenberg, 1928.

The author has divided his textbook into four parts. The first treats the problems of the hygiene of general life: the development of the modern population policy, housing, and other natural and cultural conditions of health (air, climate, soil, water, clothing, food, drink, and sewage). The second part gives a good review of the precautions in the defense of health: hygiene of the sexual life and care of health at different ages. This part also discusses the problems of tuberculosis and the care of the blind, crippled, and insane.

The third part of the book, consisting of ninety-three pages, is devoted to industrial hygiene. It gives a good review of the history of industrial hygiene and a brief summary of industrial statistics of the last few years in Germany, including tables presenting morbidity, mortality, and accident data. After a short but interesting discussion on the influence of industrialization on the population, the book deals with the question of industrial diseases. Special chapters are devoted to the problems of industrialization of the suburbs, the effect of industrialization on families, accident neuroses, Taylorism, Fordism, the dangers to sexual life from industrialization, and a review of the German industrial health laws and workmen's insurance.

The fourth part gives a review of infectious diseases: their definition, ways of transmission, portals of entrance of micro-organisms, excreta of patients, bacillus carriers, animals as sources of infectious diseases, epidemics, and the present methods of combating epidemics. This short epidemiologic discussion is followed by the description of the general morphology and biology of micro-organisms, and the essentials of immunology. There is a description of bacillary diseases and of diseases caused by protozoa and filterable virus. This part of the book ends by describing the modes of disinfection, bacterio-

logic tests, and rules regarding delivery of test materials at the place where they are to be tested.

An additional section describes the methods of testing air, water, light, and food.—*Stephen Went.*

BOOKS RECEIVED

Books received are acknowledged in this column, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers and as space permits.

PARTNERSHIPS, COMBINATIONS AND ANTAGONISMS IN DISEASE. By *Edward C. B. Ibotson*, M.D. (Lond.), B.S., Fellow Royal Society of Medicine, London. Cloth. Pp. 348 with indexes; illustrated. Philadelphia: F. A. Davis Co., 1929.

PNEUMONIA. By *Frederick Taylor Lord*, A.B., M.D., Visiting Physician, Massachusetts General Hospital. Revised edition. Cloth. Pp. 84 with title pages. Cambridge: Harvard University Press, 1929.

TEXTBOOK OF CLINICAL NEUROLOGY, FOR STUDENTS AND PRACTITIONERS. By *M. Neustaedter*, M.D., Ph.D., Visiting Neurologist, Central Neurological Hospital, Welfare Island; Formerly Lecturer in Neurology, University and Bellevue Hospital Medical College; Clinical Professor in Neurology, New York Polyclinic Medical School and Hospital; Attending Neurologist, Bellevue Hospital, Outpatient Department, Stuyvesant Polyclinic, St. Mark's Hospital; Neurologist, Kings County and City Hospital, Welfare Island, New York. With an Introduction by Edward D. Fisher, M.D., Professor Emeritus of Neurology, University and Bellevue Hospital Medical College, New York. Cloth. Pp. xx, 602 with illustrations and index. Philadelphia: F. A. Davis Co., 1929.

RACIAL HYGIENE: A PRACTICAL DISCUSSION OF EUGENICS AND RACE CULTURE. By *Thurman B. Rice*, A.M., M.D., Associate Professor of Bacteriology and Public Health, Indiana University School of Medicine; Extension Lecturer in Eugenics, Indiana University; Chairman, Indiana Eugenics Committee. Cloth. Pp. xiv, 376 with illustrations, bibliography, and index. New York: The Macmillan Co., 1929.